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RESEARCH ARTICLE

SCADA a tool to increase efficiency of water treatment plant

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ABSTRACT

SCADA is an acronym for “Supervisory Control and Data Acquisition”. SCADA applied to WTP (Water Treatment Plant) for monitoring and controlling processes that are distributed among various remote sites gives big advantage in terms of control and effective working and also provide the necessary data to control the processes. The automated water treatment and distribution systems will be an effective tool against the water quality and distribution problems. The water purification system needs to be efficiently managed and the available water resources must be effectively consumed in India. Use of SCADA system for WTP gives the efficient way to operate it economically and effectively.

Keywords: SCADA, Water Treatment Plant, Turbidity, Backwash, Rapid Sand Filtration.

QR Code for Mobile users

Conflict of Interest: None Declared

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INTRODUCTION

Water constitutes one of the important physical environments of human being and has a direct bearing on his health. Clean drinking water is a basic human need. The average daily water requirement for a person reaches up to requirement of 30 liters/day. In total of 100% of water available on earth only 0.01% of the total water of the planet is accessible for consumption. India accounts for 2.45% of land area and 4% of water resources of the world but represents 16% of the world population. With the present population growth-rate (1.9 per cent per year), the population is expected to cross the 1.5 billion mark by 2050 (Ramaprasad, 1999). Thus need to efficiently manage the available water resources is the most important problem in front of the Indian government.

The use of automated systems like SCADA is an effective way to handle the limited water resources. The SCADA increases the water quality and also it is effective for proper distribution of the water over large area. The use of automated systems continuously monitors and controls the water quality thus it gives precise and desired water quality output.

Quality Standards for Safe Water

- Objective of water treatment plant is to ensure that the water supplied is free from pathogenic organisms, clear, palatable and free from undesirable taste and odor.
- Turbidity of 1 NTU or less should be achieved.
- Disinfection of the water should be done with at least 0.5 mg/liter of free residual chlorine.

SCADA System

A SCADA system is an assemblage of computer and communications equipment designed to work together that allows an operator to monitor and control processes that are distributed among various remote sites and provide the necessary data to control processes. SCADA is usually implemented on manufacturing processes, (continuous and discrete manufacturing), treatment processes, (water and wastewater treatment), and distribution systems, (gas, oil and water pipelines). SCADA systems also perform monitoring, data logging, alarming and diagnostic functions so that large, complicated process systems can be operated in a safe manner. The SCADA system controls the sequencing and speed of pumps, and maintains run-time logs for maintenance scheduling. Thus the use of SCADA system for the water supply systems will be a most prominent solution for the problems in water treatment and distribution systems.

The SCADA system has got the following benefits: (i) Superior control and monitoring of the plant, with ease of access, (ii) Reductions in energy consumption through more efficient usage and shifting of loads to off-peak hours, (iii) Increased accuracy due to automated controls and online data analysis of parameters, (iv) Reductions in maintenance and operation efforts and costs, and (v) Increases in effective capacity through optimization of processes.

Process of Water Treatment Plant

Process of Water Treatment

The process process of water treatment plant is shown in Figure-1.

The process consists of several stages as shown in the figure as follows: (i) Aeration, (ii) Chemical handling and feeding, (iii) Coagulation and Flocculation, (iv) Sedimentation, (v) Filtration, and (vi) Disinfection (Chlorination).

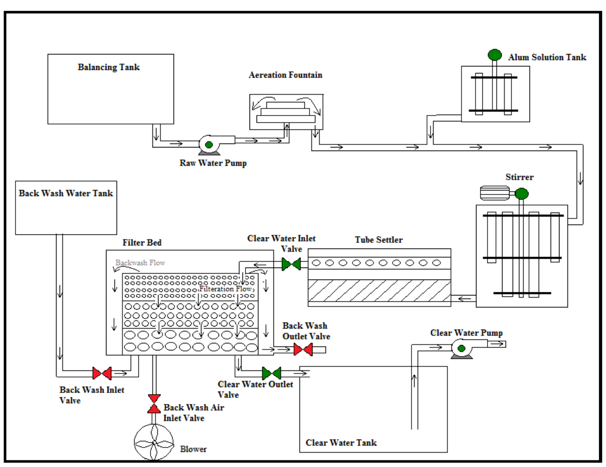


Figure-1: Water treatment plant

The same process along with its principal applications at each stage is shown in Table-1.

Process	Principle Applications
Aeration	Strips and oxidizes taste and odor causing volatile organics and gases and oxidizes iron and manganese. Aeration systems include gravity aerator, spray aerator, diffuser and mechanical aerator.
Mixing	Provides uniform and rapid distribution of chemicals and gases into the water.
Coagulation	Coagulation is the addition and rapid mixing of coagulant resulting in destabilization of the colloidal particle and formation of floc
Flocculation	Flocculation is aggregation of destabilized turbidity and color causing particles to form a rapid-settling floc
Sedimentation	Gravity separation of suspended solids or floc produced in treatment processes. It is used after coagulation and flocculation and chemical precipitation.
Filtration	Removal of particulate matter by percolation through granular media. Filtration media may be single (sand, anthracite, etc.), mixed, or multilayered
Disinfection	Destroys disease-causing organisms in water supply. Disinfection is achieved by ultraviolet radiation and by oxidative chemicals such as chlorine, bromine
Backwash	Reversing and increasing the water's flow to flush out accumulated debris and particles. To clean the filters periodically as and when required by clean water with gravity or pressure.

Table-1: Process and principal applications

In the process of chemical feeding and handling the chemicals like alum solution is added into water as per raw water quality. As the treatment is the continuous process it needs online supervision and monitoring for efficient working.

Filtration is the most relied water treatment process to remove particulate material from water.

Backwash is used to clean the filters periodically as and when required, by clean water with gravity or pressure.

The process o disinfection is performed to kill the harmful organisms and to introduce residual chlorine in the water.

2.2 Control Parameters of WTP

The process of water treatment consists of several stages for production of pure water. Each stage consist particular equipments, setup which has defined control functions. The Table-2 consists of the process equipment and control parameters for each stage.

Process	Equipment	Control Parameters

Aeration	RCC Fountain, Pump, Valve	Dissolving O_2 and remove unwanted gas, oxidation of Mg and Fe
Chemical handling and feeding	Solution tank, Turbulence channel, Stirrer	pH and turbidity testing in laboratory
Coagulation and flocculation	RCC tank, blades with gear box, Motor	Mixing of alum solution into water and formation of floc
Sedimentation	RCC tank with tube settler	Suspended particles are removed by settling
Filtration	Rapid sand filter, valve, pump	Removal of turbidity and coarse particle
Disinfection (Chlorination)	Feed valve	Chlorine dosing to remove bacteria and Residual chlorine
Backwash	Rapid sand filter, , valve, pump, Blower, Pressure gauge	Head loss across filter bed, backwash velocity, clean filter bed ,remove drain from water

Table-2: Control parameters for treatment processes

SCADA System Architecture:

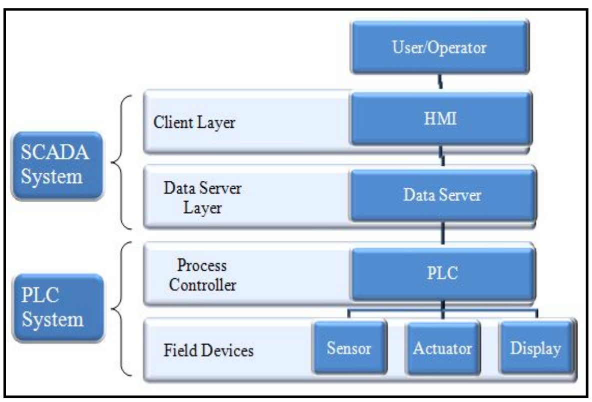


Figure-2: SCADA System Architecture

The Figure-2 shows the typical SCADA system architecture.

The field devices like valves, pumps, motors, drives etc. are connected to PLC as input output devices. These devices send the input signals to PLC which acts as the trigger to the successive events. Then PLC sends the actuation signals to various actuators to perform defined tasks. The PLC is acting as a controller for all components in SCADA system. It is a link between field devices and SCADA server.

SCADA software is acting as a monitoring device and interface between operator and the system. SCADA collects the data from field devices through PLC and stored it in memory usually on server. Also SCADA displays this data in various forms to show the performance of the system. Also SCADA system displays the current status of the system components dynamically, which gives real time control facility.

Thus for SCADA system a PLC is a controller which communicates with the field devices and a SCADA software server is a monitoring device which receives data from PLC, stores the data and processes the same for real time control.

WTP SCADA System Design

The PLC is connected to a PC nothing but the SCADA server. The server is able to run routine operation of the WTP through the PLC. The software provides an animated display of the total WTP system. The parameters of which can be controlled also by manually giving commands to the software. Also the software provides a log of the particular parameters like *pH, Turbidity, Residual Chlorine, Flow, Voltage, Current, Pumping time, Alum Stock, Frequency etc.*
The SCADA system consists of the number of and types of sensors as input device. The types of sensors required for automating the plant are:
pH sensor,
Turbidity Sensor,
Chlorine Sensor,
Ultrasonic Level Switch,
Electromagnetic Flow Sensor.
The output of PLC operates the specific *motor, pump, valves* which are the main components of WTP to be controlled. Along with these
Alum dosing Pump,
Floculator Stirrer motor,
Blower for Backwash,
Chlorine Dosing Pump for disinfection
are other devices to be controlled.
The operation of the system is fully (in Automatic mode) controlled by the PLC and SCADA software. The system components are controlled with the help of the PLC, which communicates with the software. The data sent by the PLC is stored in the server in prescribed formats; this data is used by software for decision making and report generation.

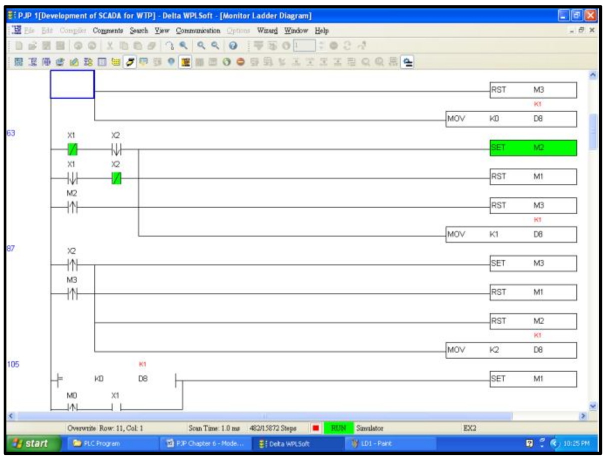
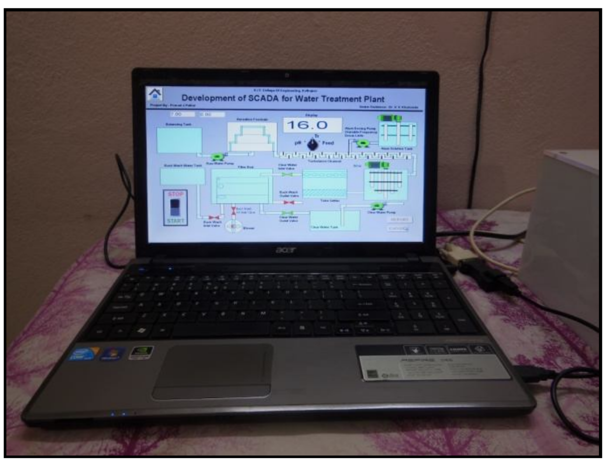


Figure-3: Developed PLC Program

The aeration of the raw water is the first process in WTP it is simple and does not require any more control than pumping.



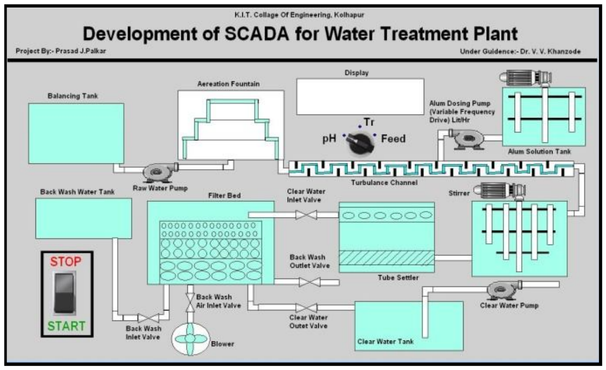


Figure-4: Screen shot of developed model SCADA system for WTP.

4.1 Chemical Dosing Control

The measurement of pH & Turbidity in the case for alum dosing is the most important task. The concentration and the feed rate of the feeding solution are in proportion of the raw water quality which may vary continuously and randomly so the online monitoring of the water quality is done by the sensors and accordingly the SCADA system prepares and add accurate solution in the water. To fulfill this requirement the pH and Turbidity sensors are used to continuously read the raw water quality.

Dosing of the prepared alum solution is done by the piston pump driven by the variable frequency drive, which can continuously adjust its feeding rate along with the incoming raw water quality.

In conventional WTP this calibration was carried out periodically in the laboratory and at the intervals of 3-4 hrs so it was less effective in case of water quality changes earlier than it. Also the feeding of the alum solution was done manually which was less efficient.

To mix this solution thoroughly in the water the stirrer blades are rotated by a motor and gearbox; the RPM of blade are controlled by the SCADA system.

4.2 Filtration and Backwash Process Control

For the filtration process through rapid sand filters the operation of the valves is main parameter controlled by the SCADA system to regulate the flow rate thorough filter bed. If the measured pressure difference along filter bed increases rated value then the SCADA system stops filtration process and starts backwash of the filter beds.

The backwash process requires more complex control. The start of backwash is decided by system by the conditions that are governing the process. For the back wash process the regular filter valves needs to be closed and the drain valve to be opened. Then the timely operation of the air blower and the backwashing water valve is the key operation of the backwash which is best handled by the SCADA system than manual operation. The use of SCADA system for this kind of operation is beneficial than convectional WTP operation.

The operation of the heavy and bulky valves is controlled by the electrical actuators very smoothly and precisely. Also the feedback signal of the valve positions gives the foolproof operation of the system.

Finally the chlorine dosing is done to introduce residual chlorine in the water for disinfection along the distribution network. The amount of the residual chlorine to be kept in water is calculated by the SCADA system and accordingly the dose is decided in purified water.

Then the final pure water pump is used to deliver the purified water along desired locations.

Features of WTP SCADA System

Some of the important features of the SCADA systems are as follows:

Control – SCADA systems are capable of running standard control algorithms like P, PI, and PID regulatory control algorithms for maintaining specific levels in tanks, maintaining prescribed flow rates. They also can also execute some form of Boolean logic for automating the starting and stopping of pumps, opening and closing of valves, and other discrete functions. SCADA systems also generally provide some sort of command set or scripting language to serve as a programming tool to allow for the need to sequence or stage these functions.

Monitoring – Providing an effective visual interface between the process and an operator is often the main function of the system. Most SCADA systems usually have a sophisticated set of tools for displaying individual process values and incorporating them into animated graphic depictions of the process. (Figure-2) They also provide the means of taking real time data and showing it as a trend so that subtle process changes may be observed. (Figure-5)

Alarming – Integrated into the data and graphical displays are alarm functions that can raise and display alarms as they occur. On some systems they can be tied into Auto-Paging and Auto-Phone-dialing features that will automatically notify operating personnel of a problem. (Figure-5)

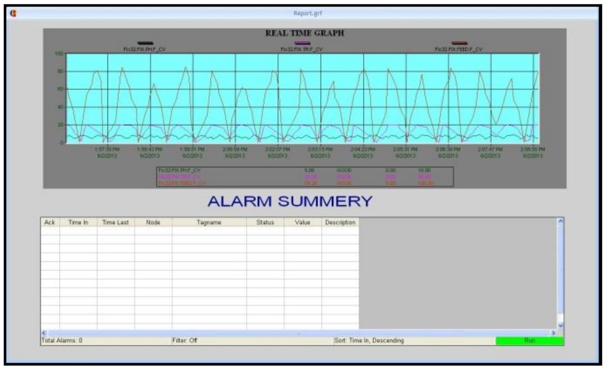


Figure-5: Trending and Alarm Summary

Data Logging – Once data has been brought into the system, the SCADA system will archive selected data into electronic records that may be recalled and reviewed at a later time. The dates and times of these events are recorded at the time of printing so they serve as a chronological record of changes that occurred within the system, i.e., what alarms occurred, what set point changes were made, and what equipment was started or stopped. (Figure-6)

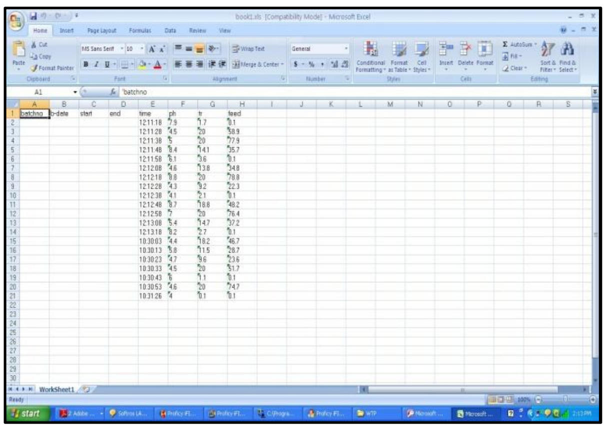


Figure-6: Data Logging using MS Excel

Diagnostic – Some SCADA systems have incorporated statistical packages that can be used for online analysis of process data to detect "when something has changed for no reason". Such changes can often be tied to drifts in calibration of instruments and/or imminent failures of control components.

Benefits of SCADA System

1. Remote Monitoring of Pressure, Fluid level, Flow rate, Leakage, filtration time, Alum Dose concentration or any other parameter on PC/Laptop/Mobile Phone and GPS Based Location Monitoring of Machines & Vehicles.
2. Energy Auditing/Management i.e., Energy Conservation can be effectively integrated with the SCADA, which helps in efficient working of the system.
3. The efficient water pumping with no or less waste of energy can be achieved.
4. The data logging function of the SCADA system provides additional benefit of accessing past records of the system operation.
5. The automated control of the system parameters considerably reduces the manpower requirement for running of the WTP.
6. The automated system gives the efficient and effective use of the chemicals for the process.
7. The integration of the different sections of the WTP allows the efficient working of the system, and provides improved control over the process.
8. Reduced errors because of the less human interference.
9. Efficient Enterprise Integration enables the parallel and smooth working of WTP.

10. The SCADA system provides the efficient water saving technique which is most important now days.

CONCLUSION

The conventional WTP systems are able to monitor the purification process manually but the efficiency of operation is less and also there is considerable delay between action and reaction. Thus there is need to have an efficient and effective system development which is resulted in more efficient and faster system.

By using a SCADA system, operator has access to critical situation wherever the manual operation may be quite slower and requires personal attention to take corrective action in time. Instead of being manually supervised plant operation engineers and automation professionals now enjoy a new tool that offers greater efficiency, thus making system more productive, while maintaining the ability to monitor the integration of real-time data, alarm, and historical information in everyday plant operations.

Since the monitoring and control of the plant process is performed with the use of computer, no additional manpower is required for system operation and supervision. The exchange of data with the SCADA system is accomplished through wired/wireless network and stored in soft format, so the expenditure of paperwork is considerably low.

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